Six new species of *Paryphantopsis* (Gastropoda: Pulmonata: Charopidae) from the Papuan Peninsula of New Guinea

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ABSTRACT

Six new species of *Paryphantopsis*, a genus of charopid snails endemic to New Guinea, are described from the geologically complex eastern terminus of the Papuan Peninsula. All descriptions are based on material collected in 2002–2003 and include information on shell, genital, and radular anatomy. Of the 14 previously described species, genital anatomy was known for three and radular morphology for only one species. Examination of these under-utilized character sets has uncovered taxonomically useful interspecific variation. The six new species appear to have distributions limited to particular mountain groups on the extreme eastern terminus of the Papuan Peninsula. Species in close proximity or sympatry share unique shell, genital and radular characters suggesting local speciation and poor dispersal ability. Diversity in *Paryphantopsis* has been underestimated and it is likely that there are many species yet to be discovered with narrow geographic and ecological ranges in the under-explored mountains of New Guinea.

INTRODUCTION

Paryphantopsis, a genus of charopid snails endemic to New Guinea, are found at moderate and high altitudes (600–4000 m) and are distributed from Western Papua (Irian Jaya) to the Louisiade Archipelago. The genus contains fourteen previously described species: *P. arcuata* Jutting, 1964, *P. dualocnsis* Solem, 1970, *P. elegans* (Fulton, 1902), *P. filosa* Jutting, 1964, *P. fultoni* (Coen, 1922), *P. globosa* (Hedley, 1890), *P. lamelligera* (Thiele, 1928), *P. latior* Jutting, 1964, *P louisiadarum* (Möllendorff, 1899), *P. platycephala* Jutting, 1964, *P. pygmaea* (Bavay, 1908), *P. sculpturata* Jutting, 1964, *P. similis* (Thiele, 1928), and *P. striata* (Fulton, 1902). Solem (1970) reviewed the genus, redescribing all species except those then recently described or reviewed by Jutting (1964). Most *Paryphantopsis* species are known from small samples of shells, often only from their type localities, and data on genital morphology are limited to three species, and on radular morphology to only one species (Solem, 1970, Wiktor, 2003). *Paryphantopsis* has not been reported previously east of longitude 148° E on the relatively poorly sampled eastern part of New Guinea, which is known as the Papuan Peninsula. The eastern end of the peninsula includes the Cloudy Mountains to the south, and the disjunct terminus of the Owen Stanley Range to the north, separated from the main Owen Stanley uplands by extensive lowlands west of Mount Suckling. The geologically complex Papuan Peninsula is formed largely by the East Papua Composite Terrane (EPCT), a tectonic province composed of at least 4 separate geological units with differing ages, origins, and histories. These units appear to have assembled northeast of modern New Guinea during the Paleocene, 62–57 Myr ago, and fused to the main body of the island in the Late Oligocene to Early Miocene, 28–22 Myr ago (Pigram and Davies, 1987). Because of its likely initial offshore amalgamation, the EPCT may have developed a distinct and largely endemic biota. This is the first in a series of papers describing the results of ten weeks of field surveys that took place during April–May, 2002 and January–March, 2003. These surveys explored the extreme eastern terminus of the Papuan Peninsula where two geological units lie in close proximity, the Cloudy Mountains of the Port Moresby Terrane and eastern terminus of the Owen Stanley Range of the Kutu Terrane (Figure 1).

MATERIALS AND METHODS

Specimens were hand-collected or sifted from samples of leaf-litter. Live collected animals were drowned overnight and then preserved in 75% ethanol. Gross anatomical dissections were made under 75% ethanol using a dissecting microscope. Radulae were isolated from dissected buccal masses using a saturated KOH solution. Scanning electron micrographs of radulae were made using a field emission SEM. Drawings of the genital anatomy were made with the assistance of a *camera lucida*, and measurements were taken using an ocular micrometer. Shell measurements were made as follows. Whorl count (W) was measured from the suture of the first whorl to the body whorl and fractions of a whorl were determined with the aid of a cardboard circle divided into 10 equal parts of 36° (Figure 2, line 1–2.9). Spire

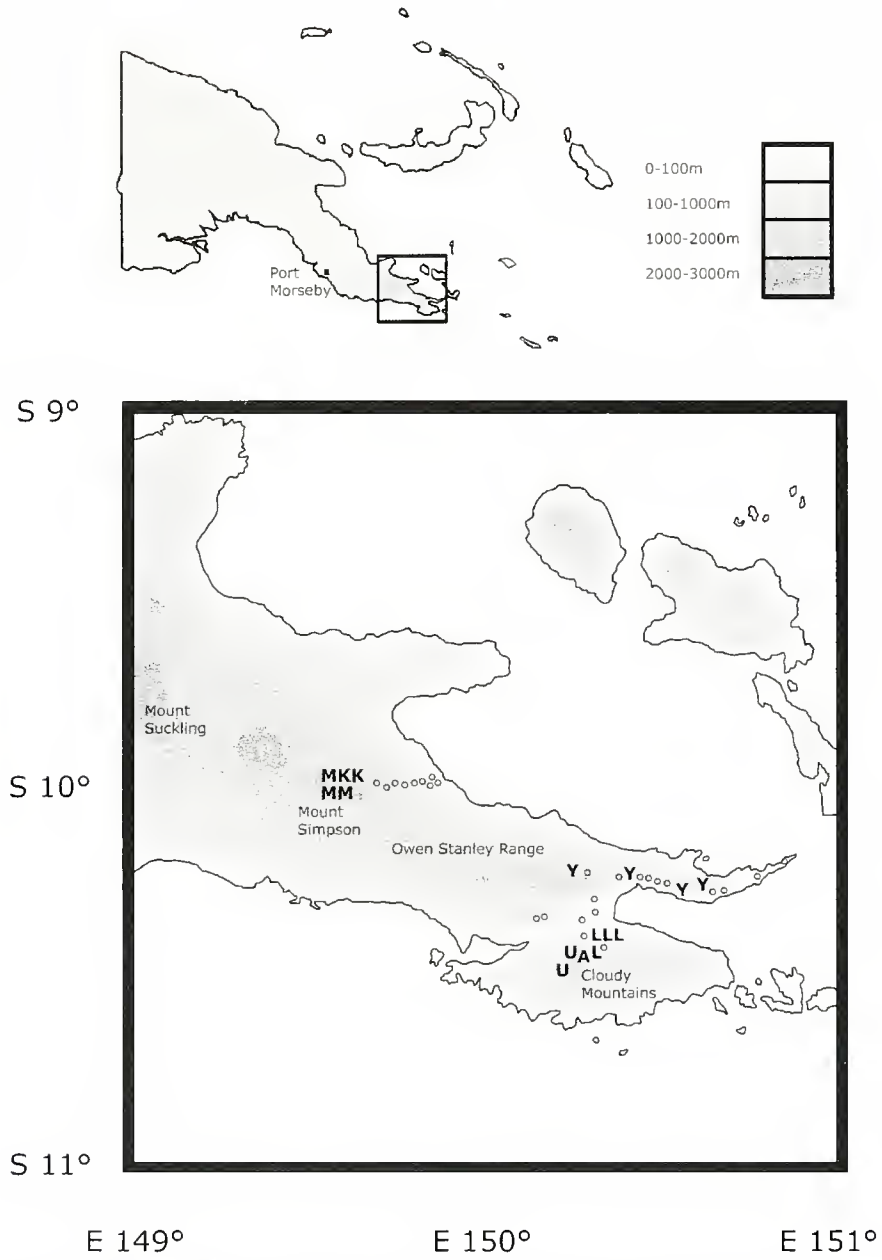
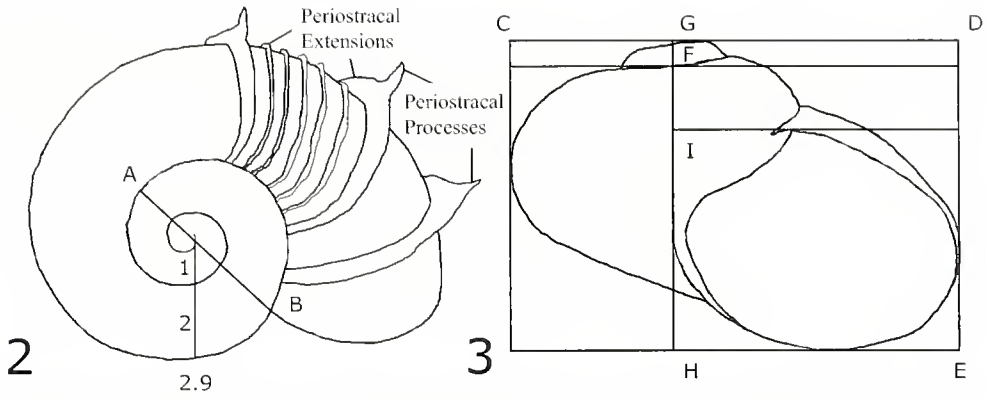


Figure 1. Distribution of *Paryphantopsis* on the eastern terminus of the Papuan Peninsula, Papua New Guinea between 9° S, 149° E and 11° S, 151° E. A = *P. abstrusa*, K = *P. koragae*, L = *P. lebasii*, M = *P. matawanensis*, U = *P. ubwamensis*, Y = *P. yawii*. O = other sites sampled.

diameter (SD) was the length of a straight line passing from the apertural edge of the suture through the middle of the apex to the opposite suture (Figure 2, line A–B). Diameter (D) was the greatest width of the shell perpendicular to the shell axis (Figure 3, line C–D). Height (H) was the greatest distance between the apex and the base of the aperture measured parallel to the shell axis (Figure 3, line D–E). Spire height (SH) was measured from the top of the body whorl to the apex of the shell (Figure 3, line F–G). Aperture width (AW) was the greatest distance from the columellar edge to the outer edge of the aperture (Figure 3, line E–H). Aperture height (AH) was measured from the suture to the base of the aperture, parallel to the shell axis (Figure 3, line H–I). The lengths of radular teeth were measured from the top of the mesocone to the posterior edge of the basal plate. The widths of radular teeth were measured as the greatest width of the cusps, not the basal plate. The following abbreviations are used in figures of genital anatomy: AT = atrium, DI = diverticulum, EP = epiphallus, OV = free oviduct, PE = penis, PG = prostate gland, PP = penial pilasters, PR = penial retractor muscle, SD = spermathecal duct, SP = spermatheca, VA = vagina, VD = vas deferens, VP = vergic



Figures 2–3. Diagram of shell measurements. **2.** Whorl count (line 1–2.9), spire width (line A–B). **3.** Diameter (line C–D), height (line D–E), spire height (line F–G), aperture width (line E–H), aperture height (line H–I).

papillae. Specimens are deposited in the following institutions: Bernice P. Bishop Museum, Honolulu (BPBM), Florida Museum of Natural History, Gainesville (UF), Papua New Guinea National Museum, Port Moresby (PNGNM), Wroclaw University Museum of Natural History (MNHW).

SYSTEMATICS

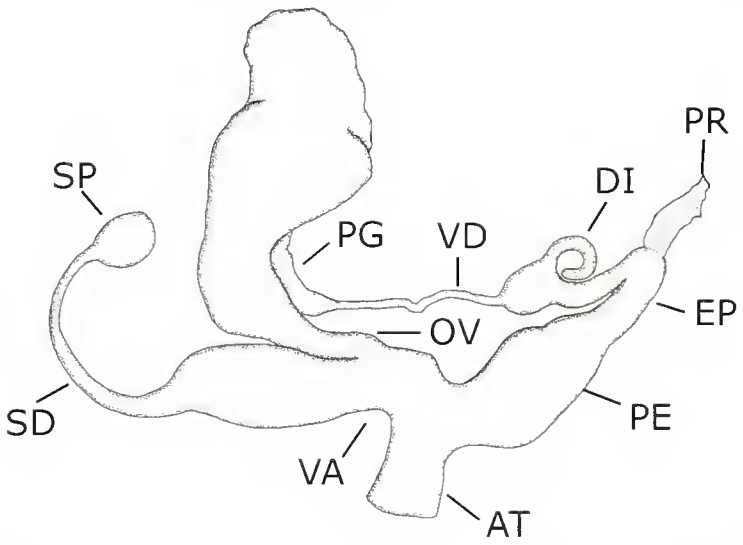
Family Charopidae Hutton, 1884
Genus *Paryphantopsis* Thiele, 1928 (Type species: *Flammulina* (*Paryphantopsis*) *lamelligera* Thiele, 1928, by original designation.)

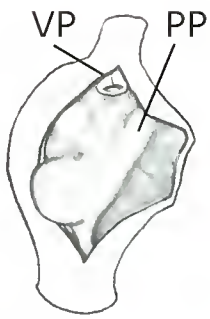
Description: Moderate to large-sized charopid snails with loosely coiled shells of approximately three whorls. Shell shape varies among species from globose to depressed with an elevated to flat spire and a rounded to keeled margin. The umbilicus, usually covered by an expansion of the peristome, is sometimes perforate. Nuclear whorls (protoconch) are sculptured with spiral rows of small pits that become weaker and less regular on later whorls. Postnuclear whorls (teleoconch) are usually sculptured with growth lines accentuated with short periostracal extensions punctuated with occasional longer extensions at regular intervals. These longer extensions can bear additional processes at the shell margin (Figure 2). A few species do not have longer periostracal extensions and some species do not bear any extensions. Body color is usually yellow in life. The epiphallus is apically inflated, often with an apical diverticulum. The penis is textured with convoluted pilasters of varying complexity. Central teeth of the radula are tricuspid and of similar size to the tricuspid and slightly assymetrical lateral teeth. The many lateral teeth become shorter and less symmetrical, grading in shape with the marginal teeth. Marginal teeth are usually assymetric, their endocones longer than their ectocones. Endocones and ectocones and less often mesocones can bear accessory cusps.

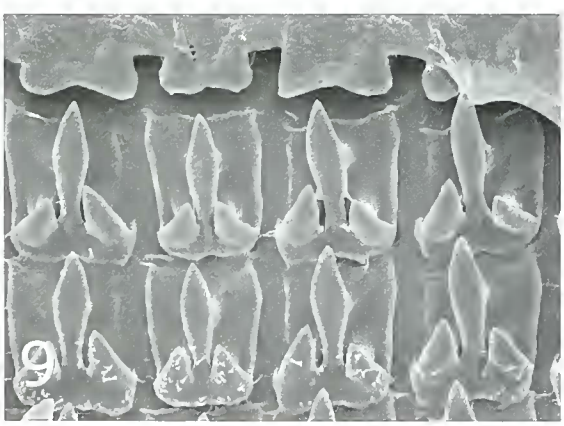
Paryphantopsis abstrusa new species
(Figures 4–10, Table 1)

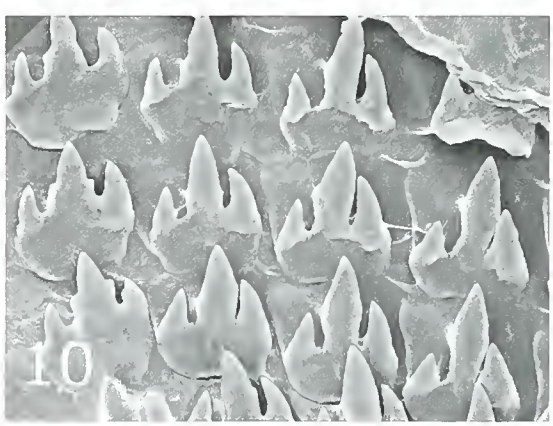
Description: The adult shell is small for the genus, 4.4–4.8 mm (mean = 4.6) in diameter and 3.5–3.8 mm (mean = 3.6) in height, with 2.9–3.0 (mean = 3.0) rapidly expanding whorls (Figures 4–6, Table 1). The spire is elevated 0.3 mm. Postnuclear whorls descend regularly and the shell height/diameter ratio is 0.76–0.81 (mean = 0.79). The shell has 1.3 evenly rounded nuclear whorls, sculptured with 12 spiral rows of small pits. The postnuclear whorls bear weak and irregular malleations, most readily visible at the base, and indistinct and irregular striae on the apical surface. The postnuclear whorls are also sculptured with weak growth lines. Approximately every fourth growth line is accentuated by a periostracal extension. The periostracal extensions bear small (0.15 mm) trigonal processes at the periphery. These processes occur on every periostracal extension for the first two whorls, then become less regular and finally absent from the final ½ whorl. The fragile processes are often partially worn from the earlier whorls of adult shells. The nuclear whorls are white, the postnuclear whorls brown. The umbilicus is closed by a reflection of the peristome. The aperture is large, ovate to nearly circular, with an aperture-diameter to aperture-height ratio of 0.54–0.67 (mean = 0.63).

The body color is uniform bright yellow-white in life, fading to cream in specimens preserved in ethanol. The vas deferens narrows rapidly from the prostate gland and remains narrow to the swollen head of the epiphallus (Figure 7). A long coiled diverticulum inserts laterally on the epiphallus soon after the junction with the vas deferens. The epiphallus narrows slightly after the diverticulum and widens towards the junction with the penis. The penis is half the length and three times the width of the epiphallus, robust, widest centrally, and narrowing slightly at each end. Apically there are several small convoluted pilasters and one much larger convoluted pilaster that extends to near the base (Figure 8). The penial retractor muscle is robust, originating from









Figures 4–10. *Paryphantopsis abstrusa*. **4–6.** Photographs of shell, Holotype UF 308235, diameter 4.6 mm. **7–8.** Camera lucida drawing of genitalia, UF 299677, maximum width 7.2 mm. **9–10.** Scanning electron micrograph of radula, UF 299677, field width of central and lateral teeth 41 µm, marginal teeth 42 µm.

Table 1. Measurements in mm of undamaged adult shells of six species of *Paryphantopsis*, N = count, H = height, D = diameter, SH = spire height, SD = spire diameter, AH = aperture height, AD = aperture diameter, W = number of whorls.

Species	N		H	D	SH	SD	AH	AD	W
P. abstrusa	3	mean ± SD	3.6 ± 0.2	4.6 ± 0.2	0.3 ± 0.0	2.1 ± 0.0	2.6 ± 0.2	2.8 ± 0.1	3.0 ± 0.1
		range	3.5–3.8	4.4–4.8	0.3–0.3	2.0–2.1	2.4–2.7	2.7–2.9	2.9–3.0
P. koragae	3	mean ± SD	2.9 ± 0.1	4.2 ± 0.0	0.2 ± 0.0	1.6 ± 0.1	2.1 ± 0.1	2.6 ± 0.1	2.8 ± 0.1
		range	2.8–3.0	4.1–4.2	0.1–0.2	1.5–1.7	2.0–2.1	2.5–2.7	2.7–2.8
P. lebasii	41	mean ± SD	3.6 ± 0.2	6.8 ± 0.5	0.1 ± 0.1	2.5 ± 0.2	2.8 ± 0.2	4.3 ± 0.4	2.8 ± 0.1
		range	3.3–4.0	6.1–7.5	0.0–0.2	2.3–2.8	2.4–3.0	3.9–4.9	2.7–2.9
P. matawanensis	5	mean ± SD	4.5 ± 0.5	7.0 ± 0.4	0.1 ± 0.1	2.6 ± 0.3	3.6 ± 0.5	4.5 ± 0.4	2.9 ± 0.2
		range	4.0–4.9	6.6–7.3	0.0–0.1	2.2–2.8	3.2–4.1	4.1–4.8	2.7–3.0
P. ubwamensis	3	mean ± SD	5.0 ± 0.2	7.1 ± 0.7	0.3 ± 0.1	3.0 ± 0.3	3.8 ± 0.3	4.3 ± 0.5	3.0 ± 0.1
		range	4.8–5.1	6.4–7.7	0.2–0.4	2.7–3.3	3.6–4.1	3.9–4.9	2.9–3.1
P. yawii	55	mean ± SD	3.1 ± 0.3	5.9 ± 0.4	0.2 ± 0.1	2.2 ± 0.3	2.3 ± 0.3	3.7 ± 0.4	2.7 ± 0.1
		range	2.6–3.6	5.0–6.5	0.1–0.3	1.9–2.6	2.0–2.7	3.2–4.1	2.6–2.8

the diaphragm and inserting at approximately mid-point on the epiphallus. The spermathecal duct is robust, narrowing abruptly at mid-point and remaining narrow until joining the relatively small, ovate spermatheca. The free oviduct joins the moderate length vagina above the atrium.

The central teeth of the radula (second row from left) are tricuspid, 8–9 µm wide and 11–12 µm long, roughly the same shape as, but smaller than, the first lateral teeth, which are 9–10 µm wide and 12–13 µm long (Figure 9). The mesocones of both the central and first lateral teeth are tall, slender, and blade-shaped, joining the rectangular basal plates close to, but not on, their posterior edge. The mesocones of the central teeth barely project beyond the anterior edge of the basal plates, those of the lateral teeth project well beyond the edge. The ectocones are trigonal and short only one third of the height of the mesocones, joining the posterior edge of the basal plates. The lateral teeth are asymmetrical, their endocones are slightly taller then their ectocones. The marginal teeth are dorsoventrally compressed and tricuspid to multicuspid, 8–9 µm wide and 11–12 µm long (Figure 10). The endocones of the marginal teeth are half the height of the mesocones and only slightly taller than the ectocones. The mesocones of the marginal teeth often bear small cusps near the mid-point.

Type Material: Holotype: UF 308235, J. Slapcinsky, 16 April 2002; Paratypes: UF 299667 (2 specimens), UF 303588 (4 specimens), type locality, J. Slapcinsky, 16 April 2002.

Type Locality: Papua New Guinea, Milne Bay Province, Cloudy Mountains, Ubwam Mountain, headwaters of the Watuti River, 10° 29.8′ S, 150° 14.02′ E, 670 m altitude.

Habitat: Observed crawling near the base of trees with smooth bark, in native forest, during wet weather at 670 meters altitude.

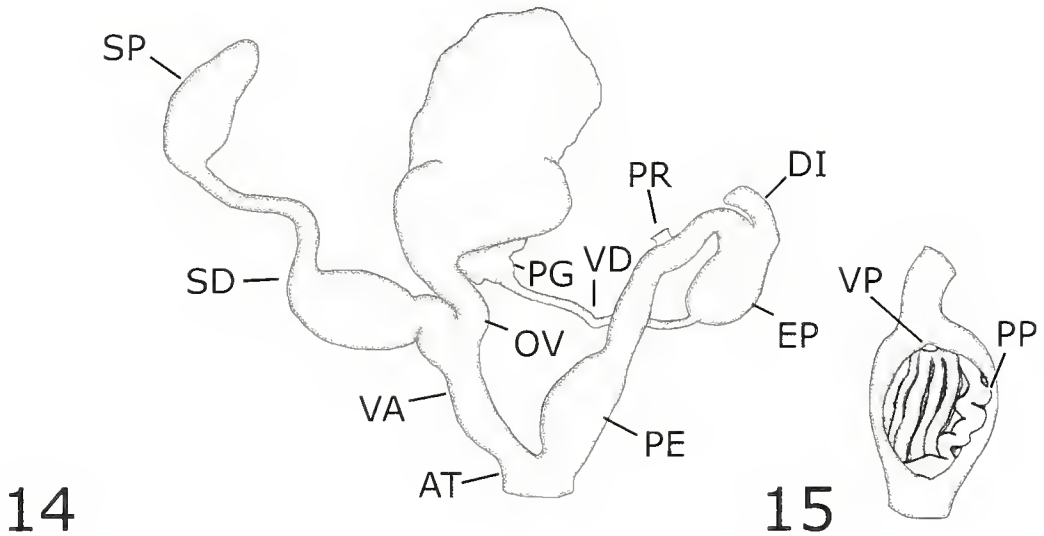
Etymology: From the Latin *abstrusa*, a feminine adjective meaning hidden, concealed and reserved, alluding to the difficulty finding this species and to its subtle almost concealed periostracal processes.

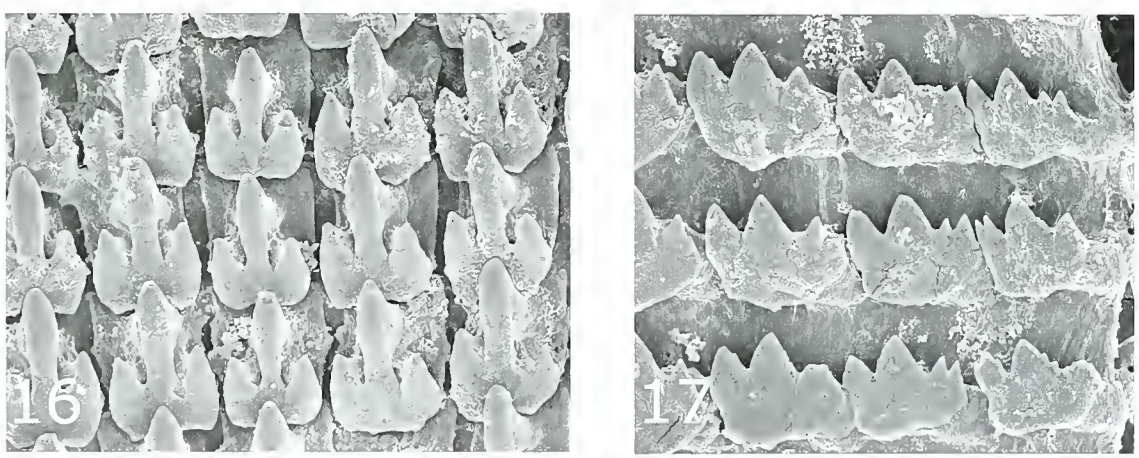
Remarks: *Paryphantopsis abstrusa* differs from most other *Paryphantopsis* smaller than 5 mm in diameter by having periostracal extensions with processes at their margins. *Paryphantopsis similis* is the only other small species with periostracal extensions. It is more depressed, with a height/diameter ratio of 0.70 compared to a height/diameter ratio of 0.79 in *P. abstrusa*.

Paryphantopsis koragae new species
(Figures 11–17, Table 1)

Description: The adult shell is small for the genus, 4.1–4.2 mm (mean = 4.2) in diameter and 2.8–3.0 mm (mean = 2.9) in height, with 2.7–2.8 (mean = 2.8) rapidly expanding whorls (Figures 11–13, Table 1). The spire is slightly elevated, 0.1–0.2 mm (mean = 0.2), postnuclear whorls descend slowly and regularly. Shell height/diameter ratio is 0.67–0.71 (mean = 0.69). There are 1.1 evenly rounded nuclear whorls, sculptured with 12 spiral rows of small pits that are not continued on the postnuclear whorls. The postnuclear whorls have regular growth wrinkles with irregular, short, periostracal extensions that are slightly weaker basally. None of the periostracal extensions extend further than the others. The nuclear whorls are white, the postnuclear whorls are dark brown. The umbilicus is closed by a reflection of the peristome. The aperture is large, flattened apically and slightly angled at the periphery and base of the columella. The aperture-diameter to aperture-height ratio is 0.78–0.80 (mean = 0.79).

The body color is uniform yellow in life, fading to cream in specimens preserved in ethanol. The vas deferens narrows rapidly after the prostate gland and remains narrow until entering the swollen, ovate head of the epiphallus (Figure 14). The interior of the head of the epiphallus bears two strong pilasters that enter the short broad diverticulum, which is roughly one quarter of the length of the epiphallus. The epiphallus is two to three times longer than the penis and one third narrower





Figures 11–17. *Paryphantopsis koragae*. **11–13.** Photographs of shell, Holotype UF 308237, diameter 4.2 mm. **14–15.** Camera lucida drawing of genitalia, UF 303586, maximum width 6.3 mm. **16–17.** Scanning electron micrograph of radula, UF 303586, field width of central and lateral teeth 55 μm, marginal teeth 41 μm.

at the junction with the penis. The very short penial retractor muscle originates on the diaphragm and inserts near the mid-point of the epiphallus. The interior of the penis bears several smooth, low, regular pilasters and one much larger convoluted pilaster (Figure 15). The spermatheca is oblong-ovate, its duct is apically narrow and widens abruptly at the mid-point. The free oviduct is relatively robust, joining the long vagina well above the atrium.

The central teeth of the radula (center row) are tricuspid, 9–10 μm wide and 12–13 μm long, slightly smaller than the first lateral teeth, which are 10–11 μm wide, 13–14 μm long (Figure 16). The mesocones of both central and lateral teeth barely project beyond the basal plate. The ectocones of the central and lateral teeth are about one half the height of the mesocones. The lateral teeth are tricuspid and very slightly assymetric with the endocone of each lateral slightly taller than the ectocone. The marginal teeth are dorsoventrally compressed and tricuspid or weakly and irregularly multicuspid, 8–13 μm wide and 8–10 μm long (Figure 17). The endocones of the marginal teeth are nearly the height of the mesocones and can have very weak secondary cusps; the ectocones are shorter and unicuspid to irregularly multicuspid.

Type Material: Holotype: UF 308237, J. Slapcinsky, 20 February 2003; Paratypes: Papua New Guinea, Milne Bay Province, Mount Matawan (Mount Simpson): UF 303586 (2 specimens), UF 303587 (2 specimens), type locality; UF 303584 (1 specimen), plateau ENE of summit, 10°2.1′ S, 149°34.6′ E, 2567 m altitude, J. Slapcinsky, 17 February 2003; UF303585 (1 specimen), Bunisi Village, 10°1.1′ S, 149°36.2′ E, 1450 m altitude, J. Slapcinsky, 16 February 2003.

Type Locality: Papua New Guinea, Milne Bay Province, Mount Matawan (Mount Simpson): NE of summit, 10°1.7′ S, 149°34.7′ E, 2100 m altitude.

Habitat: Active on plants and leaf litter usually near the ground. Observed aestivating in suspended leaf litter within 1.5 m of the ground in tropical hardwood forest and cloud forest from 1450 m to 2600 m altitude.

Etymology: This matronym honors Ms. Helen Korage, Councelor for the Village of Ikara, who facilitated our access to the Mount Matawan area.

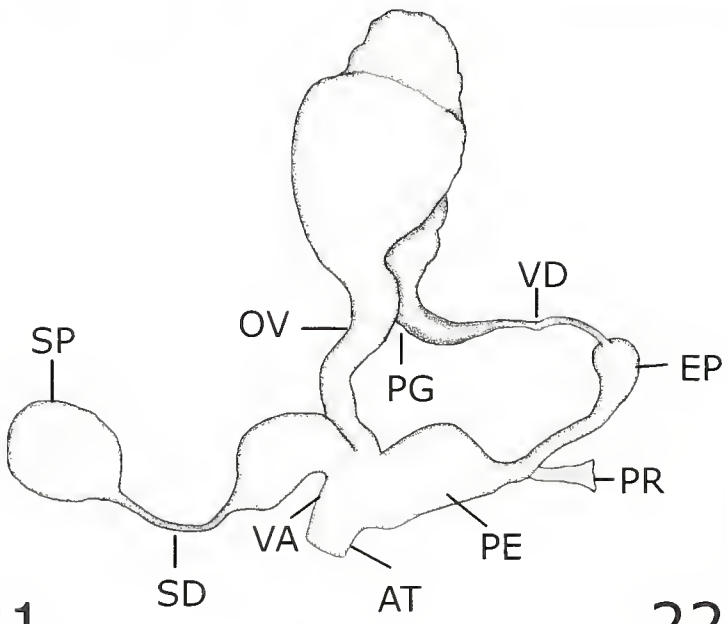
Remarks: *Paryphantopsis koragae* differs from other species of *Paryphantopsis* in being sculptured with growth lines accentuated with very short periostracal extensions. All other small species (≤ 5 mm diameter), including *P. filosa, P. pygmaea, P. arcuata, P. sculpturata, P. similis, P. platycephala,* and *P. abstrusa* have occasional longer periostracal extensions. The anatomy of only one *Paryphantopsis* species of similar size has been figured previously: *P. filosa* from Karkar Island near Madang (Wiktor, 2003, fig. 9). This species differs from *P. koragae* in not having a diverticulum on the epiphallus.

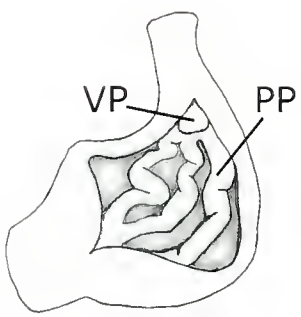
Paryphantopsis lebasii new species
(Figures 18–24, Table 1)

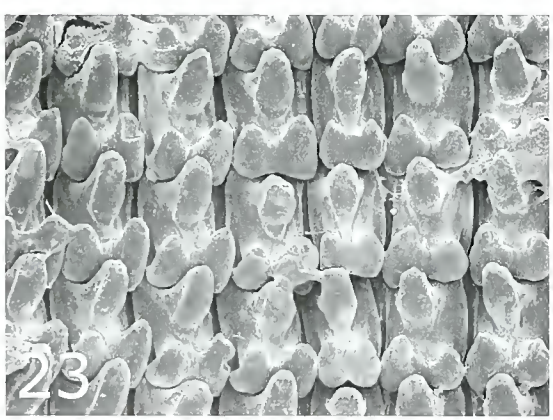
Description: The adult shell is slightly larger than average for the genus, 6.1–7.5 mm (mean = 6.8) in diameter and 3.3–4.0 mm (mean = 3.6) in height, with 2.7–2.9 (mean = 2.8) rapidly expanding whorls (Figures 18–20, Table 1). The spire is flat to slightly elevated, 0.0–0.2 mm (mean = 0.1). Postnuclear whorls descend slowly and regularly and shell height/diameter ratio is 0.45–0.61 (mean = 0.53). There are 1.3 nuclear whorls, with weak, peripheral and supraperipheral angles, and sculptured with about 12 spiral rows of small pits. These pits become larger and less regular on the postnuclear whorls, where they are visible through the periostracum as weak malleations. The sculpture of spiral rows of oblong pits is clearer where the periostracum is removed. The shell periphery is weakly keeled. Apical surface of the whorls is broadly rounded or with a very weak supraperipheral angle. Regular growth wrinkles accentuated with short periostracal extensions are present on the postnuclear whorls. On the apical surface, these extensions are folded along their length towards the aperture and are weakly appressed to the shell. Approximately every fifth periostracal extension protrudes about 0.5 mm beyond the shell margin forming large rectangular processes. These processes overlap each other on the penultimate whorl, but not on the body whorl. They are approximately equally spaced, rectangular, distally rounded, and of approximately equal length. Periostracal extensions of the growth lines are shorter, erect, and less prominent basally. Nuclear whorls are white; postnuclear whorls pale yellow brown. The umbilicus is perforate or, less often, closed, covered to varying degrees by a reflection of the peristome. The aperture is large, depressed-ovate with an aperture-diameter to aperture-height ratio of 0.51–0.75 (mean = 0.65).

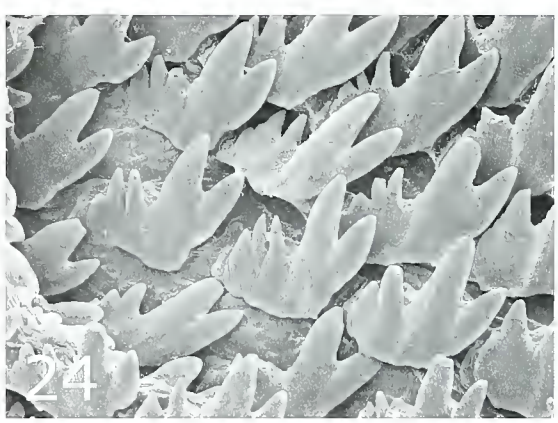
The body color is uniform bright creamy-yellow in life, fading to creamy-white in specimens preserved in ethanol. The vas deferens narrows to the junction with the ovate head of the epiphallus (Figure 21). The epiphallus is approximately one quarter the diameter of the penis and does not bear a diverticulum. The penial retractor muscle is a little less than half the length of the epiphallus, originating from the diaphragm and inserting at the base of the epiphallus. The robust penis is a little shorter than the epiphallus, with three strong pilasters that run its entire length (Figure 22). The atrium is short, expanding slightly toward the junction with the penis and vagina. The spermathecal duct is massive at the base, tapering rapidly at mid point, the remainder is relatively narrow until its junction with the spherical spermatheca. The free oviduct is slightly coiled and narrow, joining the very short vagina just above the atrium.

The central teeth of the radula (fifth row from left) are symmetrically tricuspid, 8–9 μm wide and 13–14 μm long, and are similar in shape and length to the slightly wider (9–10 μm), and slightly asymmetrical lateral teeth (Figure 23). The bluntly conical and erect mesocones of









Figures 18–24. *Paryphantopsis lebasii*. **18–20.** Photographs of shell, Holotype UF 308233, diameter 6.5 mm. **21–22.** Camera lucida drawing of genitalia, UF 299671, maximum width 6.7 mm. **23–24.** Scanning electron micrograph of radula, UF 299671, field width of central and lateral teeth 67 μm, marginal teeth 38 μm.

the central and lateral rows join their basal plates centrally and barely project beyond the anterior of their basal plates. The ectocones of both the central and lateral rows are trigonal and short, about half the height of the mesocones; they join the posterior edge of their basal plates at a low buttress. The endocones of the lateral teeth are slightly larger but otherwise of similar shape to their ectocones. The marginal teeth are dorsoventrally compressed, multicuspid, about 9–10 μm wide and 10–11 μm long (Figure 24). The endocones are nearly the same height as the mesocones while the ectocones are much shorter, about one half to one third the height of the mesocones and divided into three cusps.

Type Material: Holotype: UF 308233, J. Slapcinsky, 9 April 2002; Paratypes: Papua New Guinea, Milne Bay Province: UF 299676 (1 specimen); UF 299699 (5 specimens), Cloudy Mountains, Ubwam Mountain, headwater of the Watuti River, 10°29.8′ S, 150°14.0′ E, 675 meters altitude, J. Slapcinsky, 16 April 2002; UF 299674 (8 specimens); UF 303593 (4 specimens), Pini Range, Duabo Mission Station, 10°25′ 05″ S, 150°18′ 24 E, 325 meters altitude, J. Slapcinsky, 9 April 2002; BPBM (2 specimens); MNHW 978 (2 specimens); PNGNM 004-105 (2 specimens); UF 299671 (19 specimens); UF 303591 (1 specimen), 30 April 2002; UF 303590 (7 specimens), 2 March 2003, Pini Range, E of Duabo Mission Station, 10°25.0′ S, 150°18.6′ E, 325 meters altitude, J. Slapcinsky; UF 299677 (1 specimen), 30 April 2002; UF 303592 (1 specimen), 1 May 2002, Pini Range, abandoned logging road W of Duabo Mission Station, 10° 24.9′ S, 150° 18.3′ E, 325 meters altitude, J. Slapcinsky.

Type Locality: Papua New Guinea, Milne Bay Province, Pini Range, Duabo Mission Station, 10°25′ 04.7″ S, 150°18′ 24.4″ E, 325 meters altitude.

Habitat: Found on logs, mossy rocks and wet ground, usually near streams in disturbed and undisturbed broadleaf forest in hilly terrain from 325 to 700 meters altitude. Observed active during the day.

Etymology: This patronym honors Mr. Biga Lebasi, our host and guide at Duabo Mission Station, the type locality.

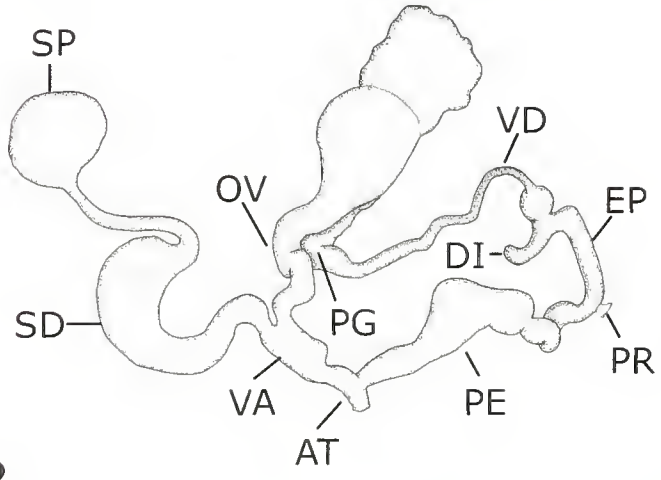
Remarks: Only four other *Paryphantopsis* species, *P. elegans*, *P. fultoni*, *P. yawii*, and *P. lamelligera* have weak to strong peripheral keels. *Paryphantopsis lebasii* is unlike all species *except P. yawii* and *P. fultoni*, in having large, rectangular periostracal extensions oriented parallel to the keeled shell margin. These peripheral extensions are all of equal length, unlike in *P. fultoni*, and do not overlap on the body whorl, unlike in *P. yawii*.

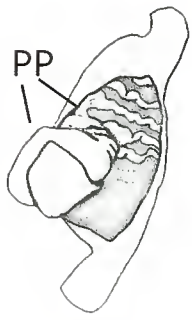
Paryphantopsis matawanensis new species
(Figures 25–31, Table 1)

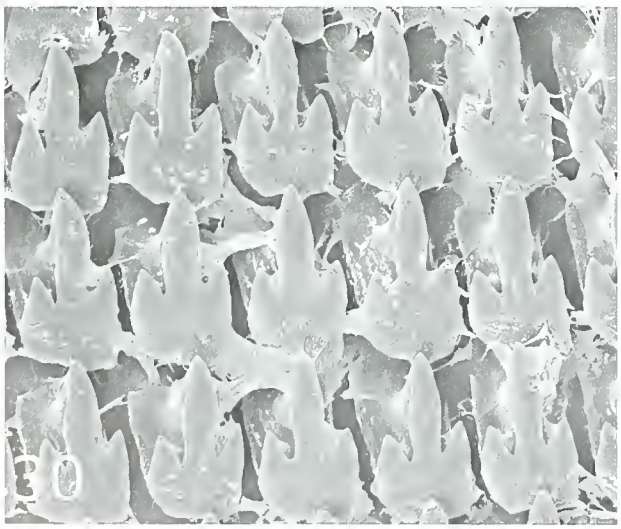
Description: The adult shell is larger than average size for the genus, 6.6–7.3 mm (mean = 7.0) in diameter and 4.0–4.9 mm (mean = 4.5) in height, with 2.7–3.0 (mean = 2.9) rapidly expanding whorls (Figures 25–27, Table 1). The spire is flat or very slightly elevated, 0.0–0.1 mm (mean = 0.1). Postnuclear whorls descend regularly and shell height/diameter ratio is 0.61–0.69 (mean = 0.64). There are 1.3 rounded nuclear whorls, sculptured with 6 spiral rows of small pits that grade into weak, spiral striae on the penultimate whorl; shell sculpture is obscured by periostracum on the body whorl. The shell is wider and slightly angular below the mid-point. The postnuclear whorls have regular growth wrinkles accentuated with low periostracal extensions that alternate with several much longer extensions approximately every 10 growth-lines. The grouping of several longer extensions appears like a single very thick periostracal extension to the naked eye. The nuclear whorls are white, the postnuclear whorls are dark brown to red-brown. A reflection of the peristome closes the umbilicus. The aperture is large, depressed-ovate, with an aperture-diameter to aperture-height ratio of 0.54–0.67 (mean = 0.63).

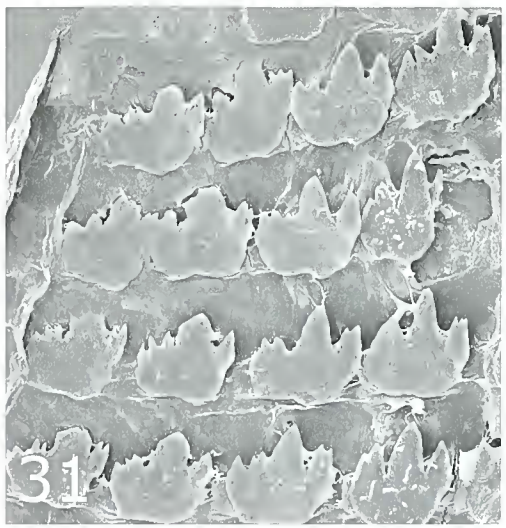
In life the body color is bright-yellow with lateral patches of dark purple-brown, the yellow fades to cream in specimens preserved in ethanol. The vas deferens narrows toward the junction with the inflated spherical head of the epiphallus. Immediately after, and perpendicular to the head of the epiphallus, there is a finger-shaped diverticulum that is roughly one quarter the length, and slightly narrower than the diameter of the epiphallus (Figure 28). The remainder of the epiphallus is somewhat twisted and approximately the same length as the penis. The penial retractor muscle is short, originating from the diaphragm and inserting on the basal third of the epiphallus. The epiphallus is roughly half the diameter of the penis. The penis expands for its apical third and then tapers basally to its junction with the similarly sized atrium. The penis apex bears several regular pilasters oriented perpendicular to the length of the penis (Figure 29). At the penis mid-point there is one very large and convoluted pilaster that extends basally. The wall of the base of the penis is thin, bearing regular small pustules. The atrium is short and narrow expanding slightly towards the junction with the penis and the long vagina. The base of the spermathecal duct is relatively narrow, about the same diameter as the base of the penis and free oviduct; it triples in size to its mid-point then narrows abruptly for the remaining third before joining the spherical spermatheca. The free oviduct is narrow, joining the long vagina well above the atrium.

The central teeth of the radula (center row) are tricuspid, 11–12 μm wide and 18–19 μm long, roughly the same size and shape as the first lateral teeth (Figure 30). The mesocones of both the central and first lateral teeth are tall and sharp, tapering apically and narrowing basally. Mesocones are attached to their basal plates along their entire length, except for their apical quarter that extend beyond the anterior margin of the basal plates. The ectocones of the central teeth and the symmetric ectocones and endocones of the lateral teeth are trigonal, about half the height of the mesocones. The mar-









Figures 25–31. *Paryphantopsis matawanensis* **25–27.** Photographs of shell, Holotype UF 308236, diameter 7.3 mm. **28–29.** Camera lucida drawing of genitalia, UF 303581, maximum width 11.7 mm. **30–31.** Scanning electron micrograph of radula, UF 303581, field width of central and lateral teeth 63 μm, marginal teeth 59 μm.

ginal teeth are dorsoventrally compressed and irregularly multicuspid, 11–12 μm wide and 10–12 μm long (Figure 31). The ectocones of the marginal teeth are slightly shorter than their endocones, which are slightly shorter than their mesocones. Both the ectocones and endocones are irregularly multicuspid, the mesocones are broadly trigonal to broadly rounded.

Type Material: UF 308236, J. Slapcinsky, 19 February 2003; Paratypes: Papua New Guinea, Milne Bay Province, Mount Matawan (Mount Simpson): UF 303581 (9 specimens), UF 303582 (3 specimens), type locality; UF 306529 (1 specimen), NE of summit, 10°2.1′ S, 149°34.4′ E, 2700 m altitude, J. Slapcinsky, 18 February 2003; UF 303583 (1 specimen), NE of summit, 10°1.7′ S, 149°34.7′ E, 2100 m altitude, J. Slapcinsky, 20 February 2003.

Type Locality: Papua New Guinea, Milne Bay Province, Mount Matawan (Mount Simpson), ridge top E of summit, 10°2.5′ S, 149°34.6′ E, 2700 m altitude.

Habitat: All specimens were collected in cloud forest from 2100 to 2700 m altitude. Individuals were observed from 1–2 m above ground, crawling on a variety of cloud forest vegetation in wet or foggy weather. In drier weather specimens were observed in leaf litter that was suspended in trees, especially in the crowns of *Pandanus* sp.

Etymology: Named for the type locality and known range of this species: Mount Matawan (Mount Simpson).

Remarks: Of the other larger (>6 mm diameter) species of *Paryphantopsis*, *P. globosa*, and *P. louisiadarum* do not have periostracal extensions on the growth lines, unlike *P. matawanensis*. Of the species with periostracal extensions, *P. latior*, *P. lamelligera*, *P. fultoni*, and *P. striata* do not have a repeating pattern of approximately 10 short periostracal extensions followed by several longer extensions. *P. matawanensis* further differs from *P. lamelligera* and *P. fultoni* in not having peripheral processes on the periostracal extensions. The genital anatomy of *P. matawanensis* differs from *P. lamelligera* in having a diverticulum.

Paryphantopsis ubwamensis new species
(Figures 32–38, Table 1)

Description: The adult shell is large for the genus, 6.4–7.7 mm (mean = 7.1) in diameter and 4.8–5.1 mm (mean = 5.0) in height, with 2.9–3.1 (mean = 3.0), rapidly expanding whorls (Figures 32–34, Table 1). The spire is elevated, 0.2–0.4 mm (mean = 0.3), the postnuclear whorls descend relatively rapidly, especially near the aperture. The shell height/diameter ratio is 0.66–0.75 (mean = 0.70). The 1.2 nuclear whorls are evenly rounded and sculptured with 12 spiral rows of small pits. These pits do not continue on the postnuclear whorls, which are sculptured only with weak growth lines that do not bear periostracal extensions. The whorls are inflated, the sutures deeply impressed, and the periphery evenly rounded. The nuclear whorls are white, the postnuclear whorls brown, with irregular lighter patches. The umbiliens is perforate, narrowed by a reflection of the peristome. The aperture is large, ovate, with an aperture-diameter to aperture-height ratio of 0.79–0.93 (mean = 0.85).

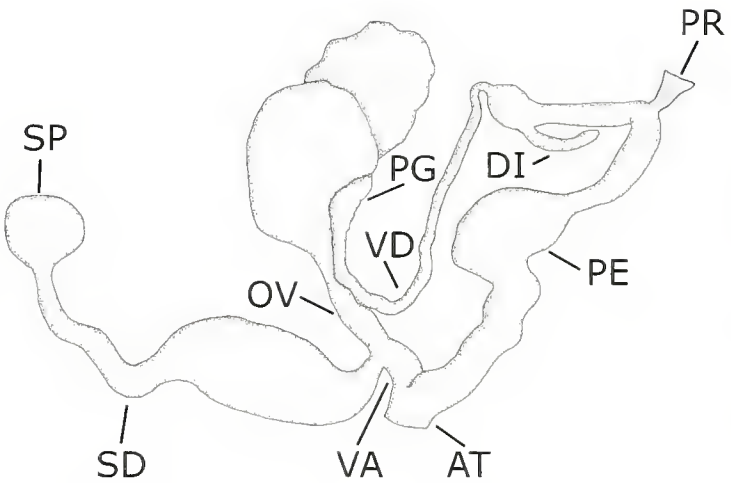
The body color is uniform yellow in life, fading to cream in specimens preserved in ethanol. The vas deferens is wide at the prostate gland, narrowing rapidly and remaining narrow until the junction with the inflated ovate tip of the epiphallus (Figure 35). The epiphallus bears a long (approximately a quarter of the length of the epiphallus), finger-shaped diverticulum just after the junction with the vas deferens. The epiphallus is about one third the diameter of the apex of the penis. The penis is broad apically, narrowing abruptly to half its apical diameter slightly before mid-point and remaining the same diameter to the junction with the atrium. The penis is sculptured with several slightly convoluted pilasters that extend in an arc from near basally to near apically, and one much larger and more convoluted pilaster near the penis mid-point (Figure 36). The penial retractor muscle originates from the diaphragm and inserts at the mid-point of the epiphallus. The spermathecal duct is basally robust and narrows at mid-point, remaining narrow until the junction with the spherical spermatheca. The free oviduct is narrow joining the moderate length vagina above the atrium.

The central teeth of the radula (center row) are tricuspid, 10–11 μm wide and 15–16 μm long, roughly the same width and shape as, but a little shorter than, the first lateral teeth, which are 18–19 μm long (Figure 37). The mesocones of both the central and lateral teeth are long, slender and blade shaped, projecting slightly beyond the basal plate. The ectocones and endocones of the lateral teeth are symmetrical and half the height of the mesocones. The marginal teeth are dorsoventrally compressed and irregularly tricuspid-multicuspid, 12–15 μm wide and 13–15 μm long (Figure 38). The endocones are tall, large to very large and sometimes irregularly multicuspid. The ectocones are unicuspid.

Type Material: Holotype: UF 303589, J. Slapcinsky, 22 April 2002; Paratypes: Papua New Guinea, Milne Bay Province, Cloudy Mountains, Ubwam Mountain: UF 299666 (1 specimen), type locality; UF 299668 (2 specimens), headwaters of the Watuti River, 10°29.8′ S, 150°14.02′ E, 670 m altitude, J. Slapcinsky, 16 April 2002.

Type Locality: Papua New Guinea, Milne Bay Province, Cloudy Mountains, Ubwam Mountain, summit, 10°30.4′ S, 150°13.5′ E, 1000 m altitude.

Habitat: This species was found crawling on a moss-covered rotting log in cloud forest at 1000 meters. Dead shells were also found at 670 meters in leaf litter at the base of a tree with smooth bark.



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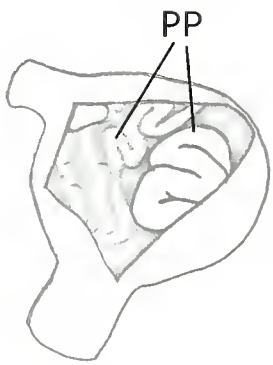

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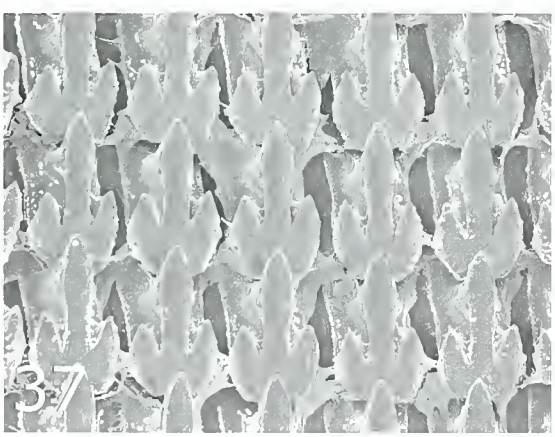


Figures 32–38. *Parryphantopsis ubvamensis*. **32–34.** Photographs of shell, Holotype UF 303589, diameter 7.7 mm. **35–36.** Camera lucida drawing of genitalia, UF 299666, maximum width 10.1 mm. **37–38.** Scanning electron micrograph of radula, UF 299666, field width of central and lateral teeth 66 µm, marginal teeth 45 µm.

Etymology: This species is named for the type locality, Ubwam Mountain, and indirectly for one of our guides who is named after the mountain.

Type Material: Holotype: Papua New Guinea, Milne Bay Province, Cloudy Mountains, Ubwam Mountain, summit, 10°30.4′ S, 150°13.5′ E, 1000 m altitude, J. Slapcinsky, 22 April 2002 (UF 303589); Paratypes: Papua New Guinea, Milne Bay Province, Cloudy Mountains, Ubwam Mountain: type locality (UF 299666, 1 specimen); headwaters of the Watuti River, 10°29.8′ S, 150°14.02′ E, 670 m altitude, J. Slapcinsky, 16 April 2002 (UF 299668, 2 specimens).

Paryphantopsis yawii new species
(Figures 39–45, Table 1)

Description: The adult shell is average in size for the genus, 5.0–6.5 mm (mean = 5.9) diameter, and 2.6–3.6 mm (mean = 3.1) height with 2.6–2.8 (mean = 2.7) rapidly expanding whorls (Figures 39–41, Table 1). The spire is elevated, 0.1–0.3 mm (mean = 0.2). Postnuclear whorls descend slowly and regularly. Shell height/diameter ratio is 0.47–0.55 (mean = 0.53). The 1.2 nuclear whorls bear rounded peripheral and supraperipheral ridges; sculptured with about 15 spiral rows of small pits. These pits become larger and less regular on postnuclear whorls but usually are obscured by the periostracum. However, pits are visible in areas where the periostracum is removed, and within the aperture. The shell has a peripheral keel and blunt supraperipheral ridge; the surface between is flattened. Postnuclear whorls are sculptured with regular growth wrinkles that are accentuated with periostracal extensions. On the apical surface of the shell, periostracal extensions are folded along their length toward the aperture and appressed to the shell except at the keeled margin where they form rectangular processes that extend about 0.5 mm beyond the shell margin. The large, distally rounded processes overlap, forming a continuous periostracal fringe of uniform length at the shell periphery. Periostracal extensions on the growth lines extend basally but are short and erect. Nuclear whorls are white, postnuclear whorls yellow brown. The umbilicus is closed by a reflection of the peristome. The aperture is large, depressed-ovate, with an aperture-diameter/aperture-height ratio 0.53–0.66 (mean = 0.63).

The body color is uniform bright creamy-yellow in life, fading to creamy-white in specimens preserved in ethanol. The vas deferens narrows toward the junction with the slightly inflated head of the epiphallus (Figure 42). The epiphallus is approximately three times longer and one quarter of the diameter of the penis and does not bear a diverticulum. The penial retractor muscle is long, about two thirds the length of the epiphallus, originating from the diaphragm and inserting on the basal third of the epiphallus. The penis is short and robust with poorly defined pilasters in the apex (Figure 43). The atrium is short and narrow, expanding slightly towards the junction with the penis and the short vagina. The base of the spermathecal duct is massive, tapering slowly but remaining broad for more than one third of its length; the remainder is relatively narrow until the junction with the spherical spermatheca. The free oviduct is slightly coiled and narrow, joining the short vagina just above the atrium.

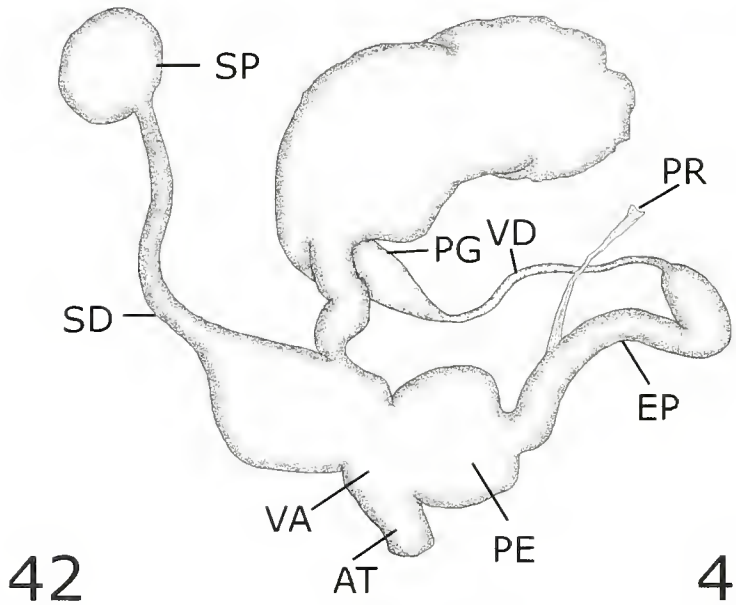
The central teeth of the radula (fifth row from left) are tricuspid, 9–10 μm wide and 14–15 μm long, roughly the same size and shape as the first lateral teeth (Figure 44). The mesocones of both the central and first lateral teeth are short, conical and erect, joining the rectangular basal plates nearly centrally and barely projecting beyond the plates' anterior margin. The ectocones are triagonal and short, only one third of the height of the mesocones, joining the posterior edge of the basal plates. The lateral teeth are asymmetrical; their endocones are slightly taller then their ectocones. The marginal teeth are dorsoventrally compressed, tricuspid to multicuspid, 8–10 μm wide and 10–12 μm long (Figure 45). The endocones of the marginal teeth are nearly the same height as the mesocones while the ectocones are much shorter, only one half to one third of their height and often divided into three cusps.

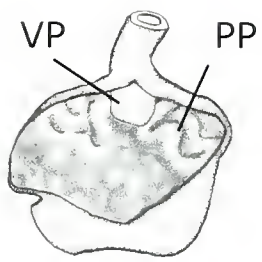
Type Material: Holotype: UF 308238, J. Slapcinsky, 6 April 2002; Paratypes: Papua New Guinea, Milne Bay Province: UF 299675 (2 specimens), UF 303594 (2 specimens), Wowow Mountain, W of Naura, 10°16.9′ S, 150°9.9′ E, 635 m altitude, J. Slapcinsky, 8 May 2002; UF 299673 (1 specimen), UF 303595 (1 specimen), 4 April 2002, UF 303598 (1 specimen), 27 February 2003, waterfall on Upalai Creek, 3 km WNW of Watunoa, 10°19.6′ S, 150°34.6′ E, 60 m altitude, J. Slapcinsky; UF 299670 (3 specimens), UF 299672 (6 specimens), 6 April 2002, UF 303596 (13 specimens), 7 March 2003, headwater of Goilavoli River at road crossing, 30 km ENE of Alotau, 10°18.7′ S, 150°37.3′ E, 275 m altitude, J. Slapcinsky; BPBM (4 specimens), MNHW 977 (4 specimens), PNGNM 004-104 (4 specimens), UF 303597 (45 specimens), small waterfall on Kinahidamadamana River near Budo Village, 10°17.1′ S, 150°26.7′ E, 125 m altitude, J. Slapcinsky, 4 March 2003.

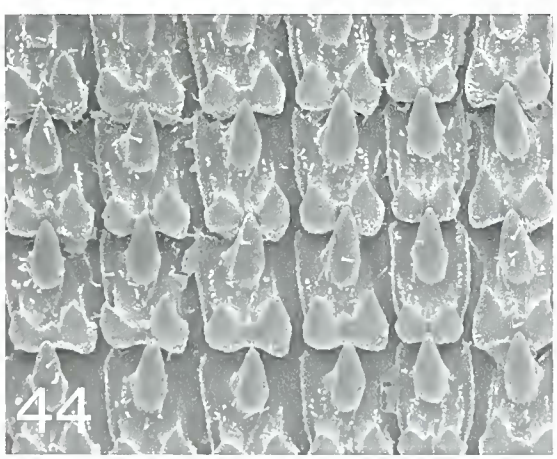
Type Locality: Papua New Guinea, Milne Bay Province, headwater of Goilavoli River at road crossing, 30 km ENE of Alotau, 10°18.7′ S, 150°37.3′ E, 275 m altitude.

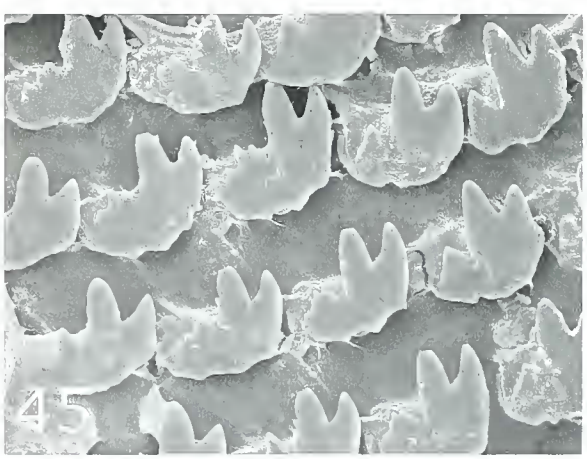
Habitat: This species was active during the day in native forest on rocks and logs with moss and algae, and on moist soil near streams. It was encountered in hilly terrain at relatively low altitudes for the genus, ranging from 60 to 635 meters.

Etymology: This patronym honors Mr. Benjamin Yawi of Budo Village, Milne Bay Province, Papua New Guinea. He and his family located, arranged permission to visit, and helped to collect at many of the sites where this species was found.









Figures 39–45. *Paryphantopsis yawii* **39–41.** Photographs of shell, Holotype UF 308238, diameter 6.5 mm. **42–43.** Camera lucida drawing of genitalia, UF 299672, maximum width 6.4 mm. **44–45.** Scanning electron micrograph of radula, UF 299672, field width of central and lateral teeth 63 μm, marginal teeth 48 μm.

Remarks: Peripheral keels are unusual among known *Paryphantopsis* species and are found only in *P. elegans*, *P. fultoni*, and to a lesser extent in *P. lebasii* and *P. lamelligera*. *Paryphantopsis yawii* is unlike all other species, except for *P. lebasii* and *P. fultoni*, in having large, rectangular periostracal extensions oriented parallel to the keeled shell margin. These peripheral extensions are all of equal length, unlike in *P. fultoni* and they overlap, forming a continuous periostracal fringe, unlike in *P. lebasii*.

DISCUSSION AND CONCLUSIONS

The family Charopidae was previously considered to be a minor component of the terrestrial molluscan fauna of New Guinea, with relatively few species and genera, and to lack the spectacular radiations exhibited by this and the related Endodontidae in the oceanic islands of the Pacific (Solem, 1983: 305). Ongoing surveys indicate that this is not the case; inadequate sampling, rather than low diversity, is the cause of the perceived low number of charopid species in New Guinea. Likewise, reports of low generic diversity of charopids in New Guinea are more likely the result of insufficient sampling and may reflect the paucity of anatomic material available to define generic units (Solem, 1970: 241). Despite the short duration and limited geographic scope of the current survey, six new species of *Paryphantopsis* are reported here, increasing the known diversity of the genus by almost 50%. In addition to *Paryphantopsis*, species belonging to several other charopid genera were also collected; these will be treated in later publications.

On the eastern terminus of the Papuan Peninsula, *Paryphantopsis* species that occur in close proximity or sympatry share unique shell, genital, and radular characters. For example, both species from the Mount Matawan area, *P. matawanensis* and *P. koragae*, have unusually short penial retractor muscles, long vaginas and angled apertural margins. Species in the uplands of the Cloudy Mountains, *P. ubwamensis* and *P. abstrusa*, are unusually tightly coiled and globose. The two lowland species, *P. lebasii* and *P. yawii*, share distally rounded rectangular periostracal processes and the unusual origin of their mesocones from the center of their basal plates. These unusual characters shared by different species in close proximity or sympatry suggest that *Paryphantopsis* species have speciated locally on a fine geographic scale; speciation in these cases is presumably facilitated by their poor dispersal ability. Because much of New Guinea remains under-explored, the true diversity of the islands' *Paryphantopsis*, other charopids, and land snails in general is almost certainly greatly underestimated.

The geographic distribution of the six *Paryphantopsis* species appears to be limited to particular mountain ranges on different terrains, despite the proximity of these mountains to each other (Figure 1). Three species, *P. matawanensis*, *P. koragae*, and *P. yawii* are restricted to the Owen Stanley Range, part of the Kutu Terrane, while three others, *P. abstrusa*, *P. lebasii*, and *P. ubwamensis*, are restricted to the Cloudy Mountains of the Port Moresby Terrane. These distinct suites of endemic species are consistent with the terrane-accretion hypothesis (Davis et al. 1997) proposed for the formation of the East Papua Composite Terrane and suggest that the low vagility and high diversity of charopids and other land snails may make them ideal to test hypotheses of terrain accretional history.

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